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Research Article

Learning Fraction using the Context of Pipettes for Seventh-Grade Deaf-Mute Student

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Abstract

The deaf-mute students have limited communication and knowledge, which result in their limitations in learning mathematics. This study aims to determine the development of the deaf-mute student in learning mathematics, especially about a fraction. The research method used is the Single Subject Research (SSR) by implementing the Indonesia Realistic Mathematics Education (IRME) approach by using the context of pipettes. The research subject consisted of one deaf-mute-male student in seventh grade at the special education public school 2 in Bantul, Indonesia who got handling in the learning process using IRME approach. The research subject was purposively chosen based on the character of a research subject who have difficulty in understanding the topic of the fraction. The research subject received eight treatments, three meetings for the baseline phase and five meetings for the intervention phase, during approximately two months. This research instrument uses videos to see the learning process and when students work on the given problems, photos to refer the results of student work, and written test in worksheets to get the data on student's work. The data analysis technique used is analyzed in conditions and between conditions with A-B research design to describe the development of student who has special characteristic in the fraction learning process. The research results show that the implementation of IRME approach using the pipette context can improve the understanding of fraction concepts and the learning outcomes of the deaf-mute student.

Keywords:
Indonesia realistic mathematics education approach, deaf-mute student, fraction, single subject research

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Introduction

One of the physical abnormalities in children is deafness that has barriers in communication because of weak hearing, resulting in limited mastery of language and knowledge (Cole & Flexer, 2015; Schick et al., 2007). Several indicators show that a child experiences hearing problems, namely not responding when spoken to, cannot speak clearly, often presses the ear, requests that the information conveyed be repeated, and the ability to speak very slowly (Thompson, 2010). Therefore, deaf student educators must be explicitly aware of the child's ability factors (Lang & Steely, 2003; Kritzer, 2009; Colin et al., 2007). Gottardis et al. (2011) argues that deaf students lag behind their hearing peers in mathematics. Thus, there needs to be increased attention and encouragement to reform mathematics in deaf education (Pagliaro, 1998; Adler et al., 2014). On the other hands, it is of great importance that deaf children have adequate access to mathematical thinking, but unfortunately, most deaf children show a severe delay in mathematics learning that has been persistent over many years (Nunes, 2014). So, deaf-mute students have limited communication and knowledge, which results in lagging behind their hearing peers in learning mathematics.

Realistic Mathematics Education (RME) has long been developed in the Netherlands in 1970 by the Freudenthal Institute which is a mathematics learning approach (Gravemeijer, 2008; Khairunnisak et al., 2012; Lestari et al., 2018; Prahmana et al., 2012). RME began to be applied in Indonesia in 2001 as PMRI (*Pendidikan Matematika Realistik Indonesia*) or Indonesian Realistic Mathematics Education (IRME) (Sembiring, 2010; Prahmana et al., 2012). IRME starts from the context (real experience) in everyday life by students towards formal mathematics of student knowledge (Khairunnisak et al., 2012; Nasution et al., 2018; Saleh et al., 2018; Karaca & Özkaya, 2017). The implementation of IRME can change mathematics learning to be more meaningful and enjoyable (Lestari et al., 2018; Prahmana et al., 2012; Maulydia et al., 2017). Therefore, the realistic mathematics education approach can transform mathematics learning into more meaningful and enjoyable through the context of daily life that is transformed into mathematical problems.

One of the mathematical problems that can be transformed in everyday life is the concept of fractions. Fractions are the essential subject matter to learn (Misquitta, 2011; Gabriel, 2016; Mujahid et al., 2017; Avcu, 2018). However, many students have difficulty understanding the concept of fractions (Nasution et al., 2018; Mousley & Kelly, 2018; Fitri & Prahmana, 2019). On the other hand, the deaf students have difficulty understanding the concept of fractions in the mathematics learning process (Markey et al., 2003; Misquitta, 2011; Mousley & Kelly, 2018). In line with the above problems, through the application of IRME, students can gradually understand the concept of fractions (Nasution et al., 2018; Saleh et al., 2018; Warsito et al., 2019). Therefore, the Indonesian Realistic Mathematics Education approach can be applied to learning fraction for deaf-mute students.

Fractions involve complex problems for students (Warsito et al., 2019; Fitri & Prahmana, 2019). The implementation of Single Subject Research (SSR) can describe the increase in fractional counting operations for fifth grade deaf students through realistic mathematics approach (Ramadhani & Tarsidi, 2017). In line with that, Warsito et al. (2019) state that with realistic mathematics learning principles, context becomes an integral part of embedding the concept of fractions. Understanding fractions is a fundamental mathematical skill, so students need to know where the fractions are in the number line (Mousley & Kelly, 2018; Fazio et al., 2016; Fitri & Prahmana, 2019). Seeing many researchers who apply realistic learning, the use of pipette contexts can make it easier for deaf-mute students to understand the concept of fractions on a number line.

Method

This type of research used the descriptive analysis with the Single Subject Research (SSR) research method which aims to determine the development of class VII deaf-mute student in fractional material. Single-subject research plays an important role in the development of evidence-based practice in special education (Horner et al., 2005). In this study of research used the A-B design. The first condition was called baseline (A), the subjects were assessed at several sessions until they appeared stable without intervention, after the baseline condition (A) stabilized the intervention condition (B) began to be applied within a certain period of time until the data was stable (Fraenkel & Wallen, 2009).

This study uses the pipette context by implementing a realistic mathematics education approach to determine the role of context in the introduction of the concept of fractions in deaf-mute students. The researcher designed the learning process in five meetings for the intervention phase, starting from the introduction of fraction using the pipette context until the implementation of the fraction to solve some daily life problem. Furthermore, the researcher used the SSR research method to describe the development of students who possessed these characteristics in the fraction learning process.

Participant

The research subject of this study was one of the seventh-grade deaf-mute students as a single subject. The student has difficulty understanding the fraction material. He is a deaf-mute student who has limited communication and knowledge, which result in his limitations in learning mathematics. Typically, he is a seventh-grade student. This research was conducted at Public Special School in Bantul, Indonesia.

Data Collection

This research was carried out in eight meeting in the even semester of the 2018/2019 academic year for approximately two months at the special education public school 2 in Bantul, Indonesia. In the first three meetings namely the baseline phase, the researcher gave a number of problems related to the topic of fraction to be solved by the student. In each meeting, the researcher only provides the explanation of how the question must be solved without providing assistance with how to solve it. The results of this phase are used as the basis for researchers in designing the learning activities that are implemented in the intervention phase. Furthermore, in the last five meetings namely intervention phase, the researcher implemented the learning activities that have been designed using the IRME approach and the pipette context. At the end of the learning process at each meeting, researchers provide problems that must be solved by student. The results obtained by students are used as a basis in the process of developing students' understanding of the topic taught namely fraction. In this research, the dependent variables are the understanding in fraction and learning outcome of student and the independent variable is IRME approach by using the pipette context.

The data collection techniques of these studies are video recordings, documentation, and written tests (Fraenkel & Wallen, 2009). The instruments used are based on data collection techniques, namely videos, photos, and written student test sheets. The video is used to describe learning activities at the intervention phase and when students work on the questions given by the researcher. Photos are used to document the learning process taking place, and the results of students' written tests are evidence in conducting research and as the material for analysis. The students' written test sheet contains the students' answer in solving the questions given by the researcher with each item validated by the lecturer as the validator. The validation process started with making a question form containing the indicators of mathematical understanding for the fraction. Each question made is developed based on the textbooks that student uses in school and the indicators designed by the researcher. Furthermore, the questions that have been made are validated by the lecturer qualitatively related to the construct and contents of the question. This instrument is used to see the effects that occur after the research is conducted.

Data Analysis

The data analysis technique uses analysis in conditions and between conditions, with A-B research design (Fraenkel & Wallen, 2009). Sunanto et al. (2005) stated that there are six phases in the analysis of circumstances. The first is the length of the term stating the number of sessions or meetings conducted during the study in the baseline phase and intervention. Second, the direct tendency is used to see the description of the behavior of the subject being studied. Third, stability trends are used to know the stability of each phase. The researcher used a stability tendency of 15%. Fourth, data traces or trend traces in each measurement phase are used to see whether the data can be said to decrease (-), up (+) or flat (=). Fifth, stability and range levels are used to see how large or small the range of data groups are in the baseline phase or intervention. Sixth, changes in level indicate the magnitude of data changes in one period.

Furthermore, the analysis between conditions is almost the same as analysis in conditions (Sunanto et al., 2005). Both of them discussed the same thing. First, the number of variables changed, namely the number of dependent variables in the study. Second one changes in the direction and effect tendencies can take the data in the analysis under conditions. Third one changes in the tendency of stability from the baseline phase to the intervention, namely to see phase changes before or after the intervention based on the analysis in the condition. Fourth, level changes are used to see changes that occur based on the difference in data points. Fifth, the overlap percentage is used to see the effect of the intervention on changes that are better or worse by the target behavior.

Results and Discussion

This research was conducted for eight days, in the baseline phase, there were three sessions, and the intervention phase was done in 5 sessions. The time or duration of the implementation of the intervention phase measurement is different for each course, according to the conditions of the student. The dependent variable in this study is the ability of the student to solve problems related to fractions. Furthermore, the independent variable is the use of the pipette context to see student learning outcomes. The student learning outcomes in this study are in Table 1.

Table 1.
Student Result

Phase	Implementation Date	Score
Baseline (A)	19 March 2019	24
	20 March 2019	28
	21 March 2019	26
Intervention (B)	25 March 2019	84
	26 March 2019	84
	27 March 2019	100
	01 April 2019	84
	02 April 2019	90

Table 1 shows the measurement of scores obtained by students in solving problems in fractions. It is seen that in the initial condition or baseline phase, the score received is deficient, while in the intervention phase, it increases, as presented in graphical form in Figure 1.

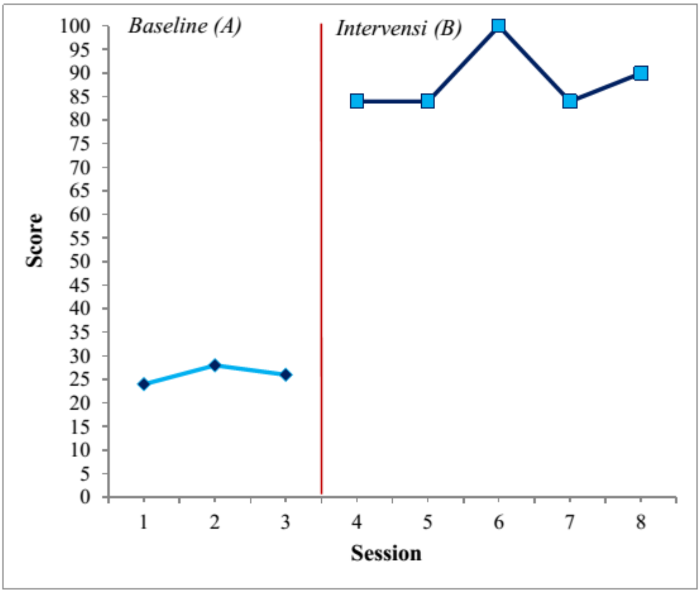


Figure 1.
The Visual Data of Baseline Phase and Intervention Phase

Furthermore, the data obtained is analyzed, namely:

1. The Analysis in Conditions
   a. Length of Condition
   Figure 1 shows a graph of student learning outcomes using A-B research design. The length of the measurement phase is three sessions for the baseline (A) and five sessions for intervention (B).
   b. Direction Tendency
   Figure 2 shows the direction trends obtained through the intersection of vertical lines that divide the same part in each phase with a graph (split-middle).

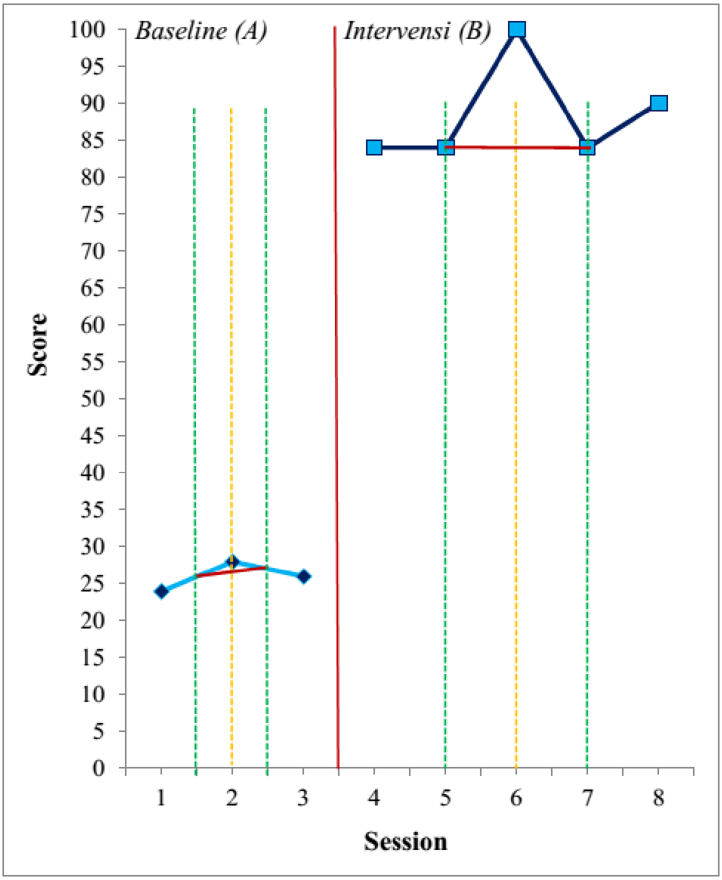


Figure 2.
Trends in Subject Direction

c. Stability Trends
The stability criteria used a stability tendency of 15% to determine the stability range, upper limit, and lower limit for each phase. The mean level, upper limit, and lower limit in the baseline phase and intervention phase. Figure 3 shows that the baseline phase data points are in the upper limit range (green) and the lower limit (purple) which is 3. The percentage of baseline phase data points that are in the range of stability is 100% then the data is declared stable. In the intervention phase there are four data points in the upper limit range (green) and the lower limit (purple). The percentage of intervention phase data points that are in the range of stability is 80% of the data is declared stable, because the range of data is at intervals of 80% - 100%.

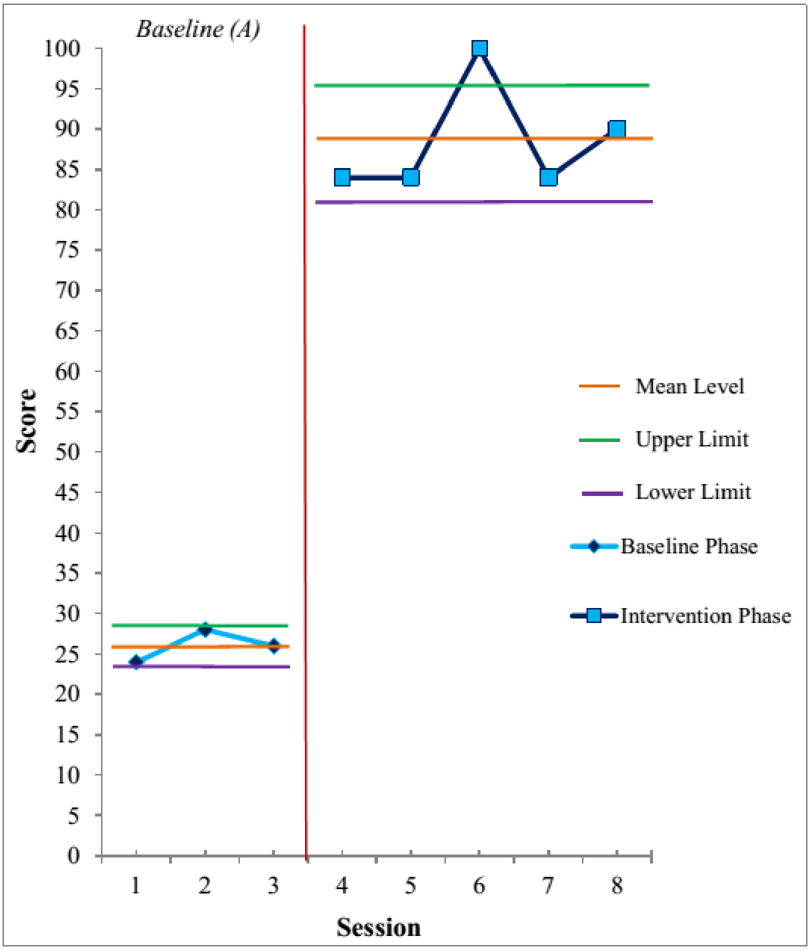


Figure 3.
Mean Level, Upper Limit, and Lower Limit in the Baseline Phase and Intervention Phase

d. Data Trace or Trace Trends
   Both phases show a flat tendency due to improved but less visible changes.
e. Stability Level
   The calculation of the level of stability of the data can be seen in the calculation of stability trends. The data baseline phase is stable with a range of $24-28$ and the data intervention phase is stable with a range of $84-100$.
f. Level Change
   In the baseline phase there was a difference of 2, meaning a change and the intervention phase obtained by the difference of 6 also showed a change (improved). All components that have been calculated can be summarized as in Table 2.

Table 2.

Summary of Visual Analysis Results in Conditions

No	Condition or Phase	A1	B2
1.	Length of Condition	3	5
2.	Direction Tendency		
3.	Stability Trends	Stable (100%)	Stable (80%)
4.	Data Trace or Trace Trends	(=)	(=)
5.	Stability Level	Stable 24 – 28	Stable 84 – 100
6.	Level Change	26 – 24 (+2)	90 – 84 (+6)

2. Visual Analysis between Conditions

   In this study an analysis was carried out between conditions by comparing the intervention phase (B) with the baseline phase (A), which is 2:1, which means that the code for the baseline phase is 1 and the intervention phase code is 2. There are several stages to analyze between conditions, namely:

   a. Number of Variables

      The variable that was changed in this study was an understanding of the concept of fraction of deaf-mute students in fractions. In Table 3, the number 1 is written which means that the variable changed is only one. In Table 3, the number 1 is written which means that the variable changed is only one.

   b. Change in Direction Tendency

      Changes in direction trends in the analysis between conditions can be determined by taking data from the analysis under conditions. Writing changes in direction trends similar to analysis in conditions, both of which have a good impact (+).

   c. Changes in Stability Trends

      Changes in the tendency of stability in the analysis between conditions can be determined by looking at the data on the tendency for stability of analysis in conditions. In this study the changes that occur from the baseline phase to the intervention phase are stable to stable.

   d. Level Change

      The last session data point of the baseline phase was 26 and the first session data point of the intervention phase was 84. Then disputed to obtain 58 for comparison of conditions B:A. Sign (+) means experiencing an increase from the previous data.

e. Percentage of Overlap

The percentage of overlap of data in the comparison of the baseline phase and intervention phase is 0%. As a small percentage overlap, the better the influence of intervention on the target behavior. All components of data analysis between conditions can be summarized as in Table 3.

Table 3.

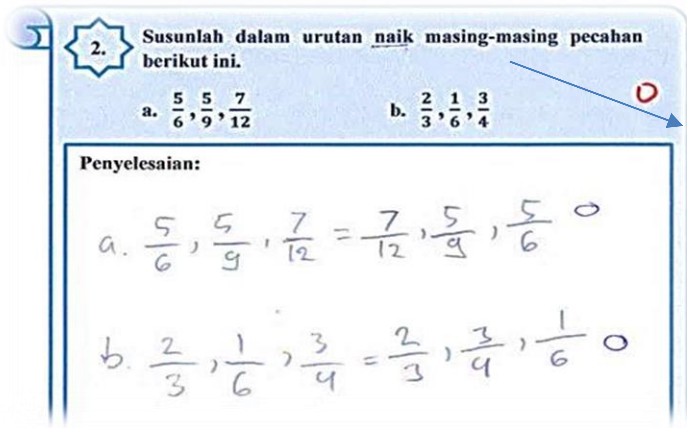
Summary of Visual Analysis Results between Conditions

No	Comparison of Conditions	B1/A1 (2:1)
1.	Number of Variables	1
2.	Change in Direction Tendency and Effect	(=) (=)
3.	Changes in Stability Trends	Stable to Stable
4.	Level Change	$(26 - 84)$ (+) 58
5.	Percentage of Overlap	0%

Based on the results of the research that has been carried out, there is an increase in the understanding of deaf students on fractional material using the pipette context. Changes that occur can be observed in the graphic image and summary analysis in Table 2 and Table 3, which includes visual analysis, analysis in conditions, and analysis between conditions in Figure 2 and Figure 3. To be clearer, researchers discuss the results of research in each phase, such as:

1. Baseline Phase (A)

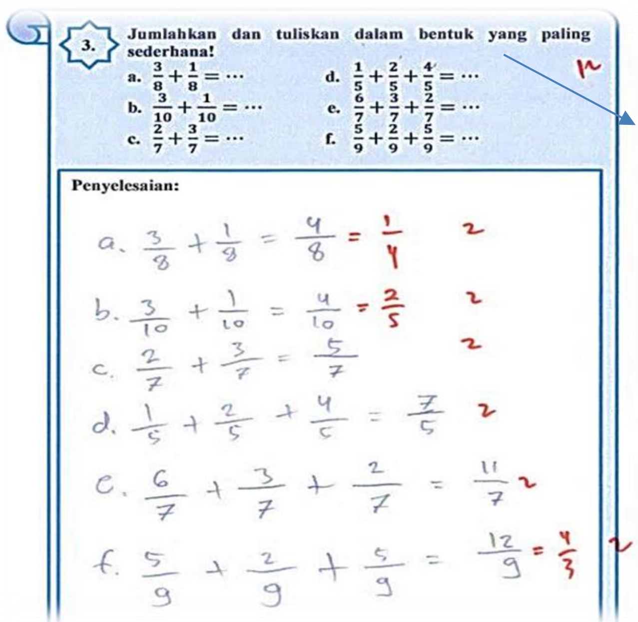
   Giving the baseline phase is carried out for three days. The baseline given to students is in the form of a written test sheet regarding fraction material. In the first session, the researcher instructed students to work on the problem, but students felt hesitant and not confident to work on the issue. Then the researcher gives direction about the matter, and students start working. The value obtained is shallow because students do not yet understand the concept of fractions related to different denominators, as seen in Figure 4.



Translate in English: Please, arrange in ascending order of each following fractions:

Figure 4.
Results of Student's Work in the Baseline Phase 1

Furthermore, in the second session, the researchers instructed students to work on the questions again. Student grades start to increase because students have started to remember a little about the concept of the same denominator. This increase in value is not much; around 1-2 points. The information can be seen in Figure 5.



Translate in English:

Please, adding and writing in the simplest form!

Figure 5.
Results of Student's Work in the Baseline Phase 2

In the third session, the students' grades declined; this was due to students not yet understanding the whole concept of fractions as in the first meeting. Measurements in the baseline phase obtained results, and the location of errors was almost the same. It shows that students experience difficulties in certain parts, namely in different denominators. Students can equate the denominator by changing all denominators in the form of least common multiple (LCM), but when operating the sum of fractions the numerator value has not been adjusted, as shown in Figure 6.

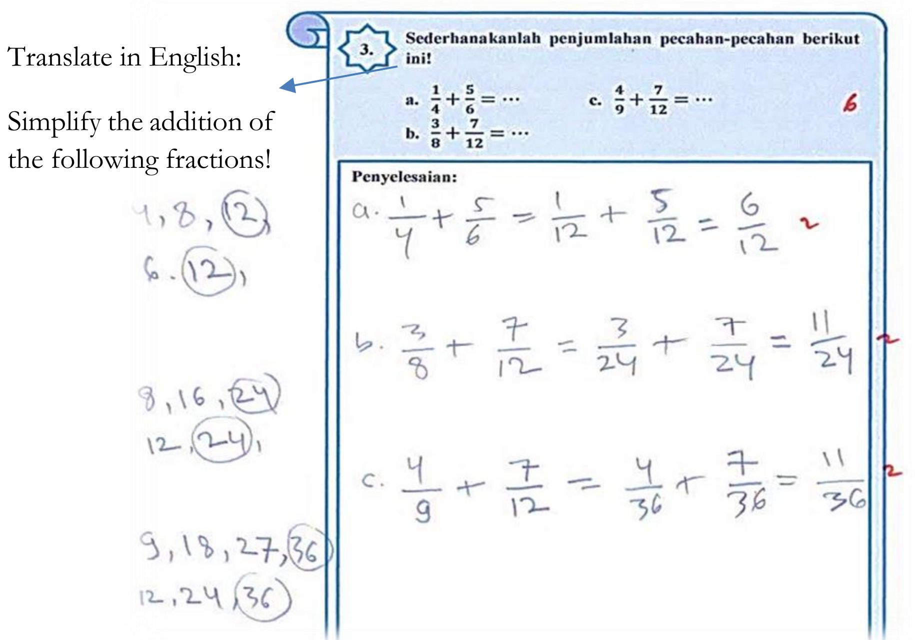


Figure 6.

Results of Student's Work in the Baseline Phase 3

The numerator adjustments that have not been done by these students, indicate the existence of prerequisites that students have not mastered before carrying out the operations of adding different fractions of the denominator. In order to study the sum of the mentioned fractions differently, there are several prerequisites that must be mastered by students, namely the sum of the same denominational fractions, fractions worth, and least common multiple (Misquitta, 2011; Pitsi, 2016; Reys et al., 2014).

2. Intervention Phase (B)

   The intervention phase was carried out for five days. Interventions given to students in the form of IRME approaches in fraction learning use the context of pipettes. This approach used is because several researcher documented their research using IRME that can be improving the students' understanding in learning fraction (Fauzan et al., 2002; Putri & Zulkardi, 2017; Shanty et al., 2011).

In the first session of the intervention phase, the researcher asks students to show a fraction. Then students show with a number line picture, however, there is a mistake in the concept of the equality fractions. Students have written number 1 in the number line, but students also write the fraction of number 1 which is 9/9 (Figure 7).

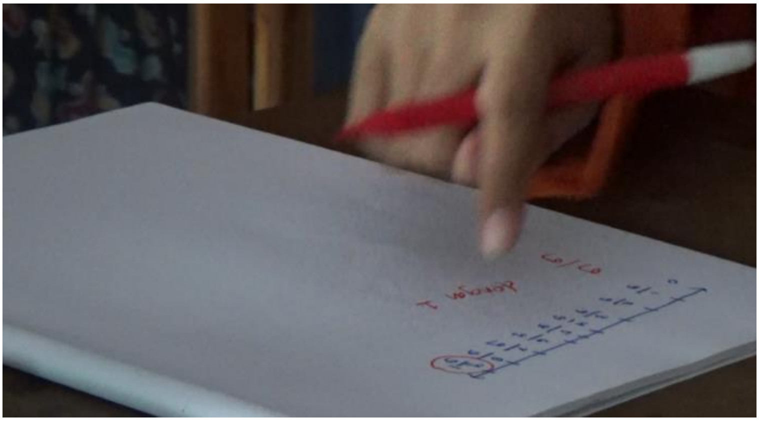
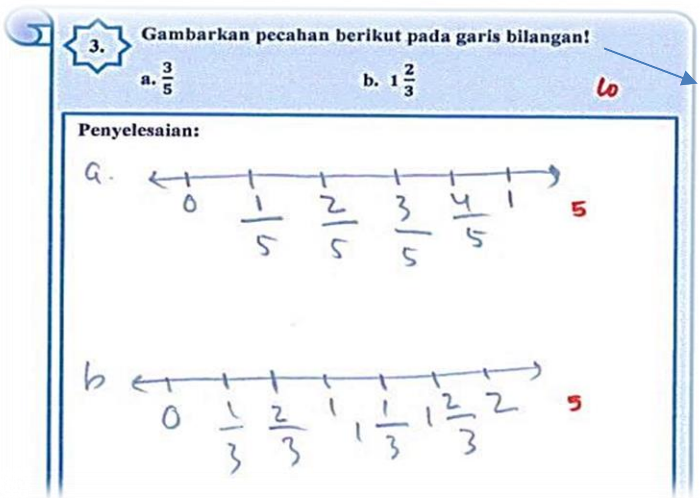


Figure 7.
The Student's Mistake in the Concept of the Equality Fractions in Number Line

Furthermore, researchers used pipettes as a medium in developing an understanding of fraction concepts, as seen in Figure 8. The pipette roles as a slide or arithmetic ruler and the bookmark roles as a point for writing the fractions. The use of pipettes is a mathematical model to emerging students' mathematical understanding from real to abstract.

Figure 8.
Use of the Pipette Context

Then the researcher instructed students to work on the written test sheets that had been given. In the first session, students can work on the questions related to the number line. So that it can be said students begin to master the concept of fractions regarding number lines. It can be seen in Figure 9.



Translate in English:

draw the following fraction on the number line!

Figure 9.
Results of Student's Work in the Intervention Phase 1

In the second session the researchers used fraction board media, as seen in Figure 10. Then the researcher gave a written test sheet to test how students understood the fraction learning.

Figure 10.
Student's Work using Fractional Rods

The results obtained show that students begin to understand the concept of fractions in sorting fractions, shown in Figure 11.

Translate in English: Please, arrange in descending order of each following fractions:

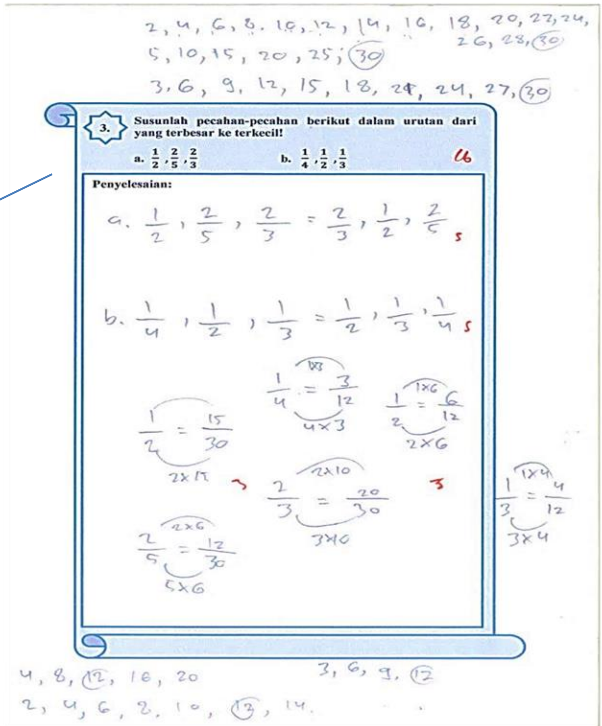
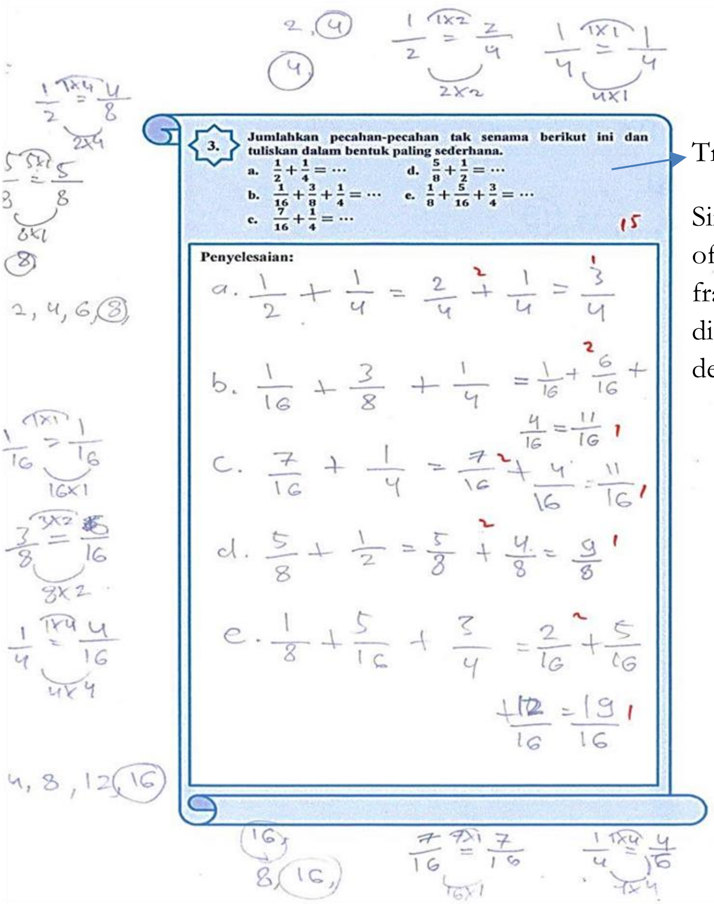


Figure 11.
Result of Student's Work in the Intervention Phase 2

Measuring the third session of the intervention phase, the researcher explained how to add different denominations to the denominator using the least common multiple. In order to obtain results from the sum of the different denominators of denominations, it must equate the denominator first by finding the least common multiple from the two denominators or fractions of value (Stafylidou & Vosniadou, 2004; Cramer et al., 2002; Siegler et al., 2011). Then the researcher instructed students to work on the written test sheet as in the previous session. The results obtained show that students can understand the explanation of the researcher well, so that the value obtained increases that can be seen in Figure 12.

Figure 12 shows that students have been able to solve the addition operations of two fractions that have different denominators. Students are able to carry out operations to equate the denominator before doing the addition operation on the numerator. For the process of equating the denominator, students look for LCM from both denominator numbers and then do multiplication operations on the numerator. The entire process of multiplication and addition in each question is able to be resolved properly, because students already have a good knowledge of number operations. The number operations is essential knowledge in solving several problem in learning mathematics, such as operation for fraction numbers (Prahmana et al., 2012; Reys et al., 2014; Prahmana & Suwasti, 2014).



Translate in English:

Simplify the addition of the following fractions that have different denominator!

Figure 12.
Results of Student Work in the Intervention Phase 3

In the fourth session the researcher gave a written test sheet to students to do as in the previous session, but the results obtained by students decreased. This is because students experience errors in calculating multiplication when equating the denominator. Thus, students are less precise when sorting fractions in descending order, as shown in Figure 13.

Figure 13 explains that students are able to carry out operations to equate the denominator process first. After all the denominators for each fraction are equal, the students sort the numerator from the highest to the lowest. To find multiplier numbers so that the denominator is the same, students use LCM on all three denominators in each fraction. The result of the LCM, also as the multiplier number in the numerator. LCM is one of the best ways to solve fraction operations that have different denominators by using the its result as a multiplier number for the numerator and denominator of the fraction (Avcu, 2018; Cramer et al., 2002; Fazio et al., 2016; Khairunnisak et al., 2012; Siegler et al., 2011), especially for deaf-mute student (Markey et al., 2003; Misquitta, 2011).

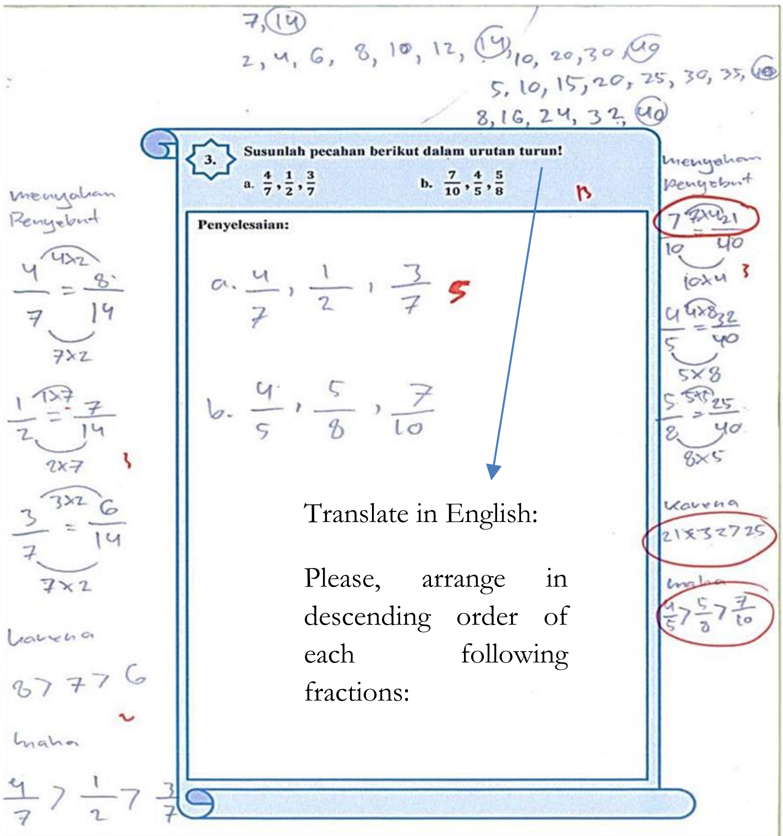
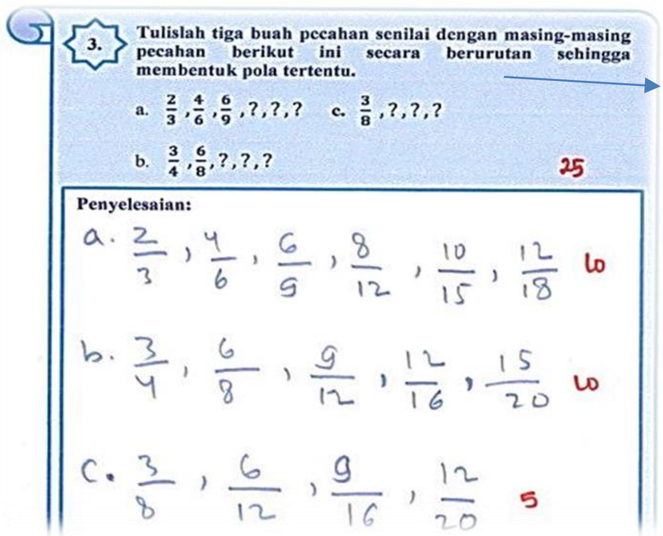


Figure 13.
Result of Student's Work in the Intervention Phase 4

Furthermore, giving the final intervention phase namely in the fifth session, the researcher instructed the students to work on the written test sheet as in the previous session. When students work on questions related to fractions of value, researchers ask students to include how to work on the question. But students feel confident and choose not to include ways to work on the problem. Thus, students experience errors when calculating in forming a certain pattern in fraction sorting, as shown in Figure 14.

Figure 14 describes that students have been able to see the pattern of each numerator and denominator in fractions. It makes the results obtained at the final meeting better. The student is directly able to multiply each numerator and denominator with a number pattern that has been found before. However, in the last problem, the student has not been able to solve the problem completely, because of his confidant.



Translate in English:

Write three equality of rational numbers of each of the following fractions in order so that they form a certain pattern.

Figure 14.
Result of Student's Work in the Intervention Phase 5

The results obtained by students in the intervention phase, showed an understanding of the fraction concept after giving the context of the pipette and fraction board based on the IRME approach in fraction learning. Thus, the IRME approach is able to improve student learning outcomes in fraction material. In accordance with previous researchers that the use of the Indonesia Realistic Mathematics Approach (IRME) has helped students understand the concept of sequential fractions (Fauzan et al., 2002; Putri & Zulkardi, 2017; Shanty et al., 2011). However, the use of concrete materials alone, i.e. the context of pipette, does not guarantee successful acquisition of mathematical concepts (Brown et al., 2009). Sarama and Clements (2009) argue that the main weakness of the context manipulative is that students can act in a way that is personally meaningful but not meaningful in the field of mathematics. They found that virtual manipulatives offer a potential solution because there is a limited set of possible actions that students can perform on them. An entirely different theoretical framework for understanding why realistic concrete materials may hinder learning: Realistic concrete materials may sometimes do too much of the work for learners (Martin, 2009). Finally, Brown et al. (2009) suggest that educators must clearly and consistently link the concrete materials with appropriate symbol systems. In order for knowledge to be transferred from concrete topics, students must understand that they do not learn about a new system isolated from mathematics; rather, they use the concrete materials to develop new knowledge and understanding of the symbol system in which they usually work.

Conclusion

The role of the pipette context in the introduction of the concept of fractions can make it easier for deaf-mute student to solve a problem related to fractions. The development of deaf-mute students in fraction learning through the pipette context based on the PMRI approach can improve for his learning outcomes. The small size of the research subject and the single subject research methodology are limitations to reduce the generalization of the research results. Therefore, the researcher recommends that the pipette context could be implemented in the class with randomly sampling with the big size of the research subject, so that that the result could be generalized. On the other hands, the researcher suggests that another researcher can develop the learning activities using another context to help the deaf-mute students in learning another topic in mathematics.

Disclosure and Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. This research is original work and does not contain any libelous or unlawful statements or infringe on the rights or privacy of others or contain material or instructions that might cause harm or injury.

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